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BREEDING BETTER BEEF. 2. EFFECT OF ANGUS, HEREFORD, AND SANTA GERTRUDIS SIRES ON PREWEANING PERFORMANCE OF CALVES

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INTRODUCTION

Genetic improvement is basic to achieving higher levels of animal productivity. Cundiff (1970) states that maximum genetic improvement will be attained when systematic crossbreeding is combined with selection among and within breeds. Crossbreeding therefore not only produces hybrid vigor but also permits the breeder to select for and combine economically important production traits from different breed sources. According to Willham (1970), breed crossing makes it readily possible to incorporate several desirable characteristics in a market animal within a short time span.

The purpose of this study was to evaluate the influence of breed of sire, breed of dam, year of birth, sex of calf, age of dam, heterosis, and crossbreeding effects on preweaning performance of calves sired by Angus, Hereford, and Santa Gertrudis bulls and out of Angus and Hereford cows.

MATERIALS AND METHODS

The data were collected over a 10-year period from 1971 to 1980 at the Mealani Experiment Station in Kamuela, Hawaii. The study included 483 male and 439 female calves. The experimental design and the number of calves weaned are shown in Table 1. The foundation cow herd consisted of grade Angus and Hereford females obtained from local ranches. All females were bred to calve first as two-year-olds. Cows were culled if they failed to calve for two consecutive years or if they sustained physical injury or disease. Angus, Hereford, and Santa Gertrudis bulls were obtained from both local and U.S. mainland sources and were selected from as many different lines of breeding as possible in order to provide a more representative sample of the breeds. Angus and Hereford bulls sired both straightbred and crossbred calves; Santa Gertrudis bulls sired crossbred calves only. Comparisons involving calves from Angus and Hereford sires provided estimates of heterosis. Calves sired by Santa Gertrudis bulls were used to estimate crossbred advantage, where the performance of Santa Gertrudis–sired calves was compared on a within-breed-of-dam basis, i.e., SGxA[1] versus the average of AxA + HxA calves, and SGxH versus the average of HxH + AxH calves.

Cows were allotted at random to mating groups. Breeding was by artificial insemination for 42 days beginning on April 1 each year followed by a 33-day period of natural service. Calves were born from January to March and remained with their dams on pasture until weaning in mid-September. Body weights were obtained on all calves within 24 hours after birth. Males were castrated at about three months of age. Weaning weights were taken at about seven months of age and were adjusted to 205 days of age by using the calf's own preweaning daily gain. The weaning conformation scores assigned to each calf represented the average grade given by three graders. Score values ranged from 9 to 11 for good, 12 to 14 for choice, and 15 to 17 for prime. All cows and calves were maintained on pasture and handled under the same management system until weaning. Pastures consisted of pangola grass (*Digitaria decumbens*) and kikuyu grass (*Pennisetum clandestinum*) fertilized with urea to provide approximately 200 lb N per acre per year. Average annual stocking rate during the period of the study was 1.5 animal units per acre. A mineral mixture containing salt, Ca, P, and trace minerals was available to all animals at all times.

The data were analyzed by least squares procedures as described by Harvey (1975). Least squares means were compared by the Newman-Keuls test for unequal subclass numbers (Sokal and Rolf, 1969). The model for all traits included the effects of year, breed of sire, breed of dam, sex, age of dam, and all first order interactions between breed of sire, breed of dam, sex, and age of dam. The traits under study included birth weight, 205-day adjusted weaning weight, average daily gain from birth to weaning, and weaning conformation score. Heritability estimates were calculated as the ratio of two times the sire component of variance to the sum of the within-sire and sire components of variance (Becker, 1975).

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[1] A = Angus, H = Hereford, SG = Santa Gertrudis. Breed of sire is listed first in all crosses.

Table 1. Number of calves weaned by breed groups

Breed of sire	Breed of dam		Total
	Angus	Hereford	
Angus	226	105	331
Hereford	104	229	333
Santa Gertrudis	133	125	258
Total	463	459	922

Table 2. Least squares means and standard errors for preweaning traits by breed of sire and breed of dam

Item[a]	N	Birth weight	205-day weaning weight	Average daily gain	Conformation[b] score
		lb	lb	lb	units
Breed of sire					
A	331	66.2 ± .8[c]	365.2 ± 3.3[c]	1.46 ± .02[c]	12.6 ± .1[c]
H	333	70.4 ± .7[d]	372.4 ± 3.7[c]	1.48 ± .02[c]	12.9 ± .1[d]
SG	258	76.4 ± .6[e]	400.8 ± 4.4[d]	1.59 ± .02[d]	13.0 ± .1[d]
Breed of dam					
A	463	69.9 ± .5[c]	385.3 ± 2.9[c]	1.54 ± .02[c]	12.9 ± .1
H	459	72.1 ± .5[d]	373.6 ± 2.9[d]	1.48 ± .02[d]	12.8 ± .1

[a]A = Angus, H = Hereford, SG = Santa Gertrudis.

[b]9 - 11 = good, 12 - 14 = choice, 15 - 17 = prime.

[c,d,e]Column means with different superscripts are different, $P < .01$.

RESULTS AND DISCUSSION

Calf performance from birth to weaning is shown by breed of sire and breed of dam in Table 2, by sex of calf and age of dam in Table 3, and by breed group subclasses in Table 4. Estimates of heterosis, crossbred advantage, and heritability are presented in Table 5.

Breed of Sire

Highly significant differences were observed in all preweaning traits between calves sired by Santa Gertrudis compared to those sired by Angus and Hereford bulls (Table 2). Santa Gertrudis bulls sired calves that exceeded Angus- and Hereford-sired calves, respectively, by 10.2 and 6.0 lb at birth, by 35.6 and 28.4 lb at weaning, and by 0.13 and 0.11 lb in average daily gain. Conformation scores for Santa Gertrudis- and Hereford-sired calves were similar, but both were higher, 0.4 and 0.3 units, respectively, than that of Angus-sired calves. Studies by Chapman et al. (1970) in Georgia have shown that Santa Gertrudis–sired calves were heavier at birth and at weaning and gained more rapidly from birth to weaning than Angus- and Hereford-sired calves. Cundiff (1970) also reported faster growth rates and heavier weaning weights for Santa Gertrudis versus Angus and Hereford calves.

Differences between calves sired by Hereford and Angus bulls were evident only for birth weight and conformation score. Hereford-sired calves were 4.2 lb heavier at birth and 0.3 units higher in conformation score than Angus-sired calves. Previous studies in Hawaii indicated no significant differences between Angus- and Hereford-sired calves in any of the preweaning traits measured (Reimer et al., 1983). Results obtained elsewhere generally agree with the present study, i.e., heavier birth weights for calves sired by Hereford bulls, but no indication of a consistent advantage in weaning weight or in average daily gain for either breed of sire (Gregory et al., 1965; Pahnish et al., 1969; Turner and McDonald, 1969; Thrift et al., 1978; Dillard et al., 1980).

Breed of sire was not found to be a significant factor responsible for death loss at calving. Analysis of the calving records in this study showed that, of all the calves lost at birth, 31 percent were sired by Angus bulls, 40 percent by Hereford bulls, and 29 percent by Santa Gertrudis bulls. The heavier birth weight associated with Santa Gertrudis–sired calves was therefore not considered to be an important cause of death loss at birth.

Breed of Dam

Differences due to breed of dam were significant for birth weight, weaning weight, and average daily gain (Table 2). Calves from Angus dams were 2.2 lb lighter at birth, 11.7 lb heavier at weaning, and gained 0.06 lb per day more rapidly than calves out of Hereford dams. Previous studies by Reimer et al. (1983) indicated a similar trend in breed of dam effects. These results agree with those published by other researchers (Gregory et al., 1965; Gaines et al., 1966; Sagebiel et al., 1973, 1974; Long and Gregory, 1974; Gray et al., 1978; Thrift et al., 1978, 1981). Gray et al. (1978) also reported higher weaning conformation scores for calves out of Angus dams.

Year Born, Sex, and Age of Dam

Year of birth was a highly significant source of variation for all traits. Birth weight, weaning weight, and average daily gain fluctuated widely between years, whereas conformation score showed a gradual increase with each successive year of the study. Similar results were reported previously by Reimer et al. (1983).

Sex of calf influenced all traits except conformation score (Table 3). Males were heavier by 4.1 lb at birth and 21.7 lb at weaning, and gained 0.08 lb per day more rapidly than females. Dillard et al. (1980) reported sex differences of 4.8 lb for birth weight, 22 lb for weaning weight, 0.1 lb for daily gain, and 0.4 units for conformation score in favor of male calves. These results are in general agreement with those presented by Lawson and Peters (1964), Brinks et al. (1972), McDonald and Turner (1972), and Thrift et al. (1978) .

The effects of age of dam were highly significant for all traits (Table 3). Calves out of two-year-old dams had the lowest performance values for all traits, whereas dams in the nine- to 13-year-old range produced the highest performing calves. The most dramatic increase in birth weight, weaning weight, average daily gain, and conformation score occurred as age of dam advanced from two to three years, as illustrated in Figure 1. Performance values for all traits increased by small increments thereafter, generally through age 13, followed by a drop for dams aged 14 years and older. The only departure from this trend was the distinctly lower level

Table 3. Least squares means and standard errors for preweaning traits by sex of calf and age of dam

Item[a]	N	Birth weight	205-day weaning weight	Average daily gain	Conformation[b] score
		lb	lb	lb	units
Sex					
M	483	73.1 ± .5[c]	390.3 ± 2.9[c]	1.54 ± .02[c]	12.9 ± .1
F	439	69.0 ± .5[d]	368.6 ± 2.9[d]	1.46 ± .02[d]	12.8 ± .1
Age of dam, years					
2	27	57.5 ± 2.6[c]	290.0 ± 15.2[c]	1.13 + .07[c]	11.7 ± .3[c]
3	92	69.1 ± 1.1[d]	352.5 ± 5.7[d]	1.38 ± .02[d]	12.6 ± .1[d]
4	114	70.7 ± .9[de]	372.5 ± 4.9[e]	1.47 ± .02[e]	12.7 ± .1[d]
5	102	72.4 ± .9[de]	377.6 ± 5.3[ef]	1.49 ± .02[ef]	12.9 + .1[d]
6	81	73.2 ± 1.1[de]	380.5 ± 5.7[ef]	1.50 ± .02[ef]	13.0 ± .1[d]
7	77	74.2 ± 1.1[e]	385.1 ± 5.7[ef]	1.52 ± .02[ef]	13.0 ± .1[d]
8	85	74.3 ± 1.1[e]	397.1 ± 5.7[ef]	1.57 ± .02[ef]	13.1 ± .1[d]
9	77	74.7 ± 1.3[e]	404.8 ± 7.5[f]	1.61 ± .04[f]	13.1 ± .2[d]
10	91	74.3 ± 1.1[e]	404.7 ± 5.7[f]	1.61 ± .02[f]	13.1 ± .1[d]
11	64	72.6 ± 1.3[de]	391.4 ± 6.8[ef]	1.55 ± .02[ef]	12.8 ± .2[d]
12	45	73.8 ± 1.3[de]	405.6 ± 7.9[f]	1.62 ± .04[f]	13.1 ± .2[d]
13	28	68.7 ± 1.8[d]	398.2 ± 9.9[ef]	1.61 ± .04[ef]	13.2 ± .2[d]
14+	39	68.2 ± 1.5[d]	372.8 ± 8.2[ef]	1.49 ± .04[ef]	12.7 ± .2[d]

[a] M = male, F = female.

[b] 9 - 11 = good, 12 - 14 = choice, 15 - 17 = prime.

[c,d,e,f] Column means with different superscripts are different, $P < .01$.

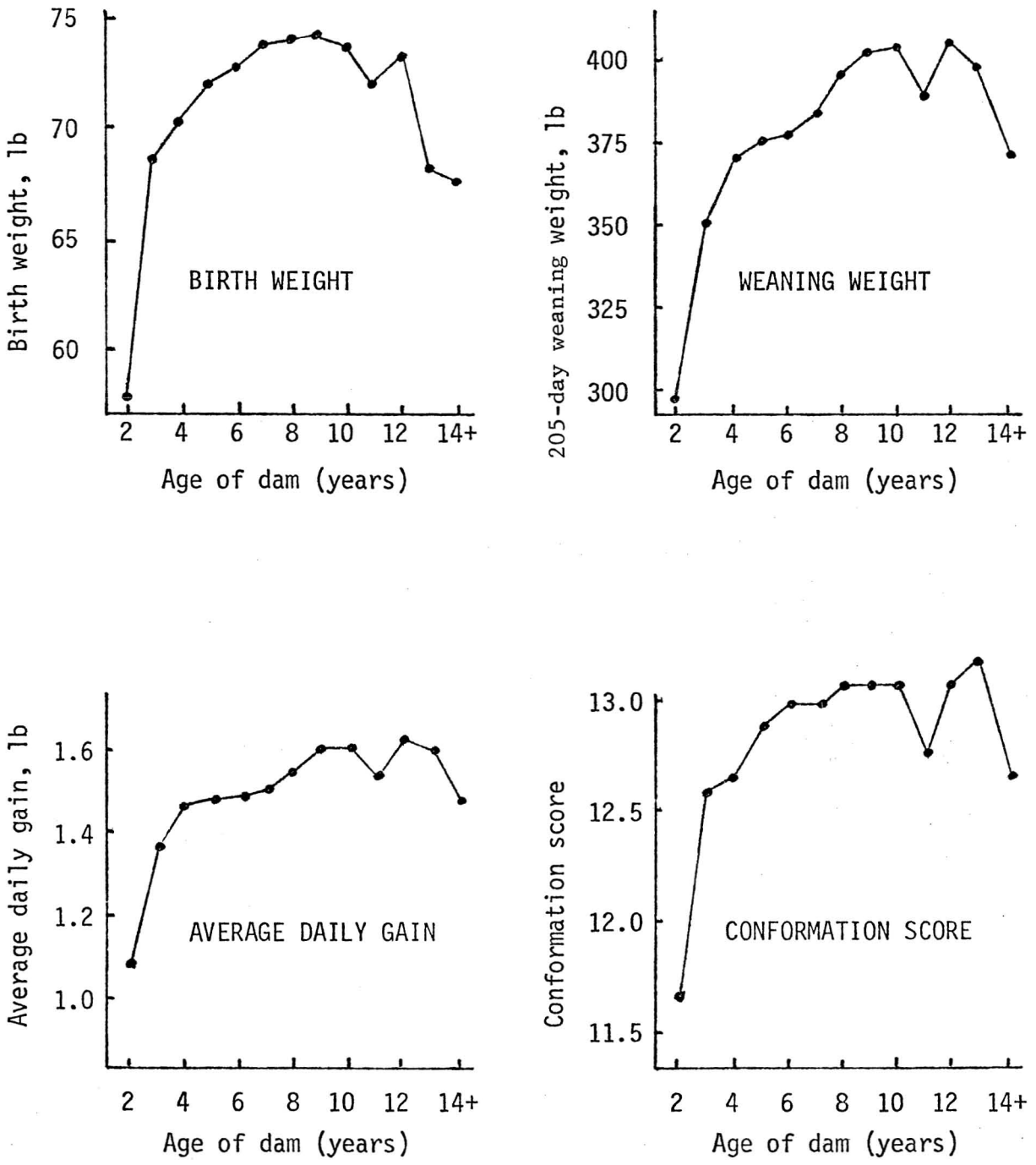

Figure 1. Effect of age of dam on preweaning traits of calves.

of performance in all traits for calves from 11-year-old dams. No plausible explanation is seen for this phenomenon. Dillard et al. (1980) reported similar increases in these traits as age of dam advanced from two to four years. Results from studies by Marlowe and Gaines (1958), Swiger (1961), Hamann et al. (1963), and Marlowe et al. (1965) showed comparable trends. However, Gregory et al. (1979) found that four-year-old Hereford and Angus dams produced calves that were heavier at birth and at weaning and gained more rapidly from birth to weaning than calves out of dams five years old and older.

Breed Groups

The influence of breed group on calf performance, as shown in Table 4, indicates a fairly consistent ranking for the breed groups in each of the four traits measured. Two obvious groupings are evident: The SGxA, SGxH, and HxA breed groups were above average in all traits, whereas the AxH and straightbred groups were below average. The SG-sired breed groups ranked first in all traits, with the SGxA group being the heaviest at weaning and highest in daily growth rate. Calves in the HxA group were only slightly lower in weaning weight and average daily gain; these differences were not significant. The only significant difference noted between breed groups performing at below average levels was the heavier birth weight for calves from the HxH and AxH breed groups as compared to straightbred Angus calves.

Heterosis

Heterosis is the difference between the performance of crossbred calves and the average performance of calves from the straightbred parental breeds. Estimates of heterosis were obtained by comparing the performance of Angus-Hereford reciprocal cross calves with the average performance of straightbred Angus and Hereford calves. The calf performance data shown in Table 4 were used to

Table 4. Least squares means and standard errors for preweaning traits by breed groups

Breed[a] group	N	Birth weight	205-day weaning weight	Average daily gain	Conformation[b] score
		lb	lb	lb	units
AxA	226	64.4 ± .6[c]	364.0 ± 3.3[c]	1.46 ± .02[c]	12.6 ± .1[c]
HxH	229	69.5 ± 1.2[d]	356.7 ± 4.2[c]	1.41 ± .02[c]	12.8 ± .1[cde]
AxH	105	68.1 ± 1.0[d]	366.4 ± 5.3[c]	1.46 ± .02[c]	12.6 ± .1[cd]
HxA	104	71.4 ± 1.0[d]	388.0 ± 5.5[d]	1.54 ± .02[d]	13.0 ± .1[cde]
SGxA	133	74.0 ± 1.0[e]	403.9 ± 5.3[d]	1.61 ± .02[d]	13.0 ± .1[de]
SGxH	125	78.8 ± .9[f]	397.7 ± 5.3[d]	1.57 ± .02[d]	13.1 ± .1[e]

[a]A = Angus, H = Hereford, SG = Santa Gertrudis. Breed of sire is shown first in all crosses.

[b]9 - 11 = good, 12 - 14 = choice, 15 - 17 = prime.

[c,d,e,f]Column means with different superscripts are different, $P < .01$.

Table 5. Estimates of heterosis, crossbred advantage, and heritability for preweaning traits

Item[a]	Birth weight		205-day weaning weight		Average daily gain		Conformation[b] score	
	lb	%	lb	%	lb	%	units	%
	Heterosis[c]							
AxH	1.2	1.7	6.1	1.7	.03	1.7	-.1	-.8
HxA	4.5	6.6**	27.6	7.7**	.11	7.3**	.3	2.4*
	Crossbred advantage[d]							
SGxA	6.1	9.0**	27.9	7.4**	.11	7.3**	.2	1.6**
SGxH	10.0	14.5**	36.2	10.0**	.14	9.4**	.4	3.2**
Heritability[e]		45 ± 8**		39 ± 8**		33 ± 7**		76 ± 10**

[a]A = Angus, H = Hereford, SG = Santa Gertrudis.

[b]9 - 11 = good, 12 - 14 = choice, 15 - 17 = prime.

[c]Heterosis, units: (e.g.) AxH minus ½(AxA + HxH)

Heterosis, %: (e.g.) $\frac{\text{Heterosis in units}}{\frac{1}{2}(\text{AxA} + \text{HxH})} \times 100$

[d]Crossbred advantage, units: (e.g.) SGxA minus ½(AxA + HxA)

Crossbred advantage, %: (e.g.) $\frac{\text{Crossbred advantage in units}}{\frac{1}{2}(\text{AxA} + \text{HxA})} \times 100$

[e]Based on 61 sires and 922 calves.

*P < .05, **P < .01.

arrive at the heterosis estimates presented in Table 5. Heterosis effects were significant for all traits among HxA calves: 6.6 percent for birth weight, 7.7 percent for weaning weight, 7.3 percent for average daily gain, and 2.4 percent for conformation score. Differences between AxH and straightbred calves were nonsignificant: 1.7 percent for birth weight, weaning weight, and average daily gain and −0.8 percent for conformation score. Earlier studies by Reimer et al. (1982, 1983) also showed higher levels of heterosis for HxA than for AxH crosses. This differential response in hybrid vigor between reciprocal crosses indicates a higher maternal ability for Angus females. Average heterosis based on the means of the reciprocal crosses, however, was significant: 4.2 percent for birth weight, 4.7 percent for weaning weight, and 4.9 percent for average daily gain. These results are somewhat higher than those reported by Dillard et al. (1980), who gave values for AxH and HxA crosses, respectively, of 0 and 3.6 percent for birth weight, 1.2 and 7.5 percent for weaning weight, 1.4 and 6.9 percent for average daily gain, and 0.6 and 2.7 percent for conformation score. Their overall average estimates for the two breed crosses were 1.8, 4.4, 4.2, and 1.7 percent for the traits above, respectively. Gray et al. (1978) reported heterosis estimates of 0, 4.8, and 1.8 percent for birth weight, weaning weight, and conformation score, respectively, from studies based on the Angus and Hereford breeds.

Crossbred Advantage

Significant crossbred advantage was observed for all traits in both SGxA and SGxH calves (Table 5). As in the case of heterosis, the calf performance data from Table 4 were used to arrive at the crossbred advantage values shown in Table 5. Crossbred advantage for SGxA calves, calculated as the difference between SGxA and the average of AxA+HxA calves, amounted to 9.0 percent for birth weight, 7.4 percent for weaning weight, 7.3 percent for average daily gain, and 1.6 percent for conformation score. Santa Gertrudis x Hereford calves exceeded the average of HxH + AxH calves by 14.5 percent in birth weight, 10.0 percent in weaning weight, 9.4 percent in average daily gain, and 3.2 percent in conformation score. Similar results were reported by Chapman et al. (1970) at the Georgia station, who found that backcross and three-breed crossbred calves sired by Santa Gertrudis bulls were heavier at birth and at weaning than calves sired by Angus and Polled Hereford bulls.

Heritability

Observed heritability estimates were significant for all traits evaluated. Heritability estimates obtained were 45.0 ± 8 percent for birth weight, 39.0 ± 8 percent for weaning weight, 33.0 ± 7 percent for average daily gain, and 76.0 ± 10 percent for conformation score. These results are considerably lower for weaning weight than those reported previously in Hawaii by Francoise et al. (1973), who gave values of 72 percent for Angus and 82 percent for Hereford cattle. Results reported elsewhere are in relatively good agreement with those in the present study. Values of 22, 37, 40, and 37 percent for birth weight and 25, 25, 30, and 45 percent for weaning weight were presented by Swiger (1961), Swiger et al. (1962), Vogt (1971), and Woldehawariat et al. (1977), respectively. Estimates given for conformation score include 15 percent by Koch and Clark (1955), 36 percent by Vesely and Robison (1971), and 24 percent by Barlow and Dettmann (1978).

Conclusions

These results substantiate previous findings by Reimer et al. (1983) that significant levels of heterosis in preweaning traits may be realized from crosses between the Angus and Hereford breeds, notably where the Angus is used as the dam breed. The increased growth and weaning weight response of Santa Gertrudis–sired calves over that of Angus- and Hereford-sired calves indicates that the Santa Gertrudis, as a breed of sire, offers a practical means by which these traits can be improved in herds of predominantly Angus and Hereford breeding. The heritability values obtained for growth rate, weaning weight, and conformation score are of sufficient magnitude to indicate that selection can also be used as an effective method for the improvement of these traits.

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